

*The Royal College of Surgeons
from the Translator*

ON

TWO ATTEMPTS

TO

ASCEND CHIMBORAZO.

BY

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TWO ATTEMPTS TO ASCEND CHIMBORAZO.

THE highest mountain-summits of both continents,—in the old continent, Dhawalagiri (White Mountain) and the Jawahir ; in the new, the Sorata and the Illimani,—remain unreached by man. The highest point of the earth's surface attained, lies in South America on the south-east side of Chimborazo. There travellers have reached the height of nearly 18,500 Paris feet*—viz. in June 1802, 3016 toises,† in December 1831, 3080 toises, above the level of the sea. Barometrical measurements have thus been made, in the chain of the Andes 3720 (Paris) feet above the level of the summit of Mont Blanc. The height of Mont Blanc is in relation to that of the Cordilleras so inconsiderable, that in the latter, there are much frequented passes that are higher ; indeed, the upper part of the great city of Potosi has an elevation only 323 toises inferior to that of the summit of Mont Blanc. I have thought it needful to premise these numerical statements, in order to present to the imagination definite points of comparison for the hypsometric, as it were plastic, contemplation of the surface of the earth.

The attainment of great heights is of less scientific interest, when the same lie far above the snow-line, and can be visited for a few hours only. Immediate barometrical measurements of heights afford indeed this advantage, that the results are quickly obtained, yet the summits are, for the most part, surrounded by high plains, adapted for trigonometrical operations, by which all the elements of the measurements can be repeatedly proved ; whilst a single determination by means of the barometer, is liable to considerable errors, because of the ascending and descending currents of air on the mountain slopes, and the variation in the decrease of temperature thus occasioned. The nature of the rocks, from the permanent covering

* One French foot is = 1.07892, or about $1\frac{1}{4}$ English.—Tr.

† A toise is = 1.94904 metres, or 6.39459 English feet.—Tr.

of snow, is almost entirely withdrawn from geognostic observation, since there are presented only single ridges composed of much weathered strata. Organic life ceases in these lofty solitudes. Scarcely do the condor and winged insects stray into these attenuated strata of the atmosphere, the latter being carried up by the currents of air. If the endeavours of travelling natural philosophers, who strive to climb the higher summits of the earth, is scarcely rewarded by a serious scientific interest, there is, on the other hand, an active popular participation in such endeavours. That which seems unattainable has a mysterious attractive power; we wish that all should be explored,—at least attempted, though not to be obtained. Chimborazo has been the wearisome object of all inquiries addressed to me since my first return to Europe. The thoroughly exploring of the most important laws of nature, the most vivid delineations of stratified zones of plants and differences in climates, determining, as the latter do, the object of agriculture, were seldom capable of diverting attention from the snow-clad summit which at that time (before Pentland's journey to Bolivia) was supposed to be the culminating point of the dike-like Andes.

I shall here extract from the still unprinted portion of my journals, the simple narration of a mountain journey. The entire detail of the trigonometrical measurement, which I made at New Riobamba in the plain of Tapia, was made known in the introduction to the first volume of my *Astronomical Observations*, soon after my return. The geographical distribution of the plants on the acclivity of Chimborazo and the neighbouring mountains (from the sea coast up to a height of 14,800 feet), I have attempted to represent, by a figure in a table of my *Geographical and Physical Atlas of South America*, according to the excellent determination by Kunth of the alpine vegetation of the Cordilleras, collected by Bonpland and myself.

The history of the ascent itself, which can present but little dramatic interest, was reserved for the fourth and last volume of my journey towards the equatorial regions. But since my friend M. Boussingault, now Professor of Chemistry at Lyons, one of the most talented and learned travellers of modern times, has recently, at my request, described in the *Annals de Chimie*

et de Physiques,* this enterprize, which very closely resembles my own,—and since our observations are mutually confirmative of each other,—this small fragment of a journey, which I here lay before the public, will no doubt be favoured with an indulgent reception. I shall provisionally refrain from all circumstantial geognostic and physical discussions.

On the 22d June 1799, I was in the crater of the Peak of Teneriffe. Three years afterwards, almost on the same day (the 23d June 1802), I reached a point 6700 feet higher, near the summit of Chimborazo. After a long delay in the tableland of Quito, one of the most wonderful and picturesque regions of the earth, we undertook the journey towards the forests of the Peruvian bark trees of Loxa, the upper course of the river Amazons, westward of the celebrated strait (Pongo de Manseriche), and through the sandy desert along the Peruvian coast of the South Sea towards Lima, where we were to observe the transit of Mercury on the 9th November 1802. On a plain covered with pumice-stone,—where (after the fearful earthquake of 4th February 1797) the building of the new city Riobamba was begun,—we enjoyed for several days a splendid view of the bell or dome-shaped summit of Chimborazo. We had the clearest weather, favouring trigonometrical observation. By means of a large telescope, we had thoroughly examined the snow-mantle of the mountain, still 15,700 toises distant, and discovered several ridges, which, projecting like sterile black streaks, converged towards the summit, and gave some hope that, upon them, a firm footing might be obtained in the region of eternal snow. Riobamba Nuevo lies within sight of the enormous and now indented mountain Capac-urcu, called by the Spaniards El Altar, which (says a tradition of the natives) was once higher than Chimborazo, and after having been many years in a state of eruption, suddenly fell in. This terror-spreading event is said to have taken place shortly before the conquest of Quito by the Inca Tupae-Yupanqui. Riobamba Nuevo must not be confounded with the old Riobamba of the great map of La Condamine and Don Pedro Maldonado. The latter city was entirely

* See Edinburgh New Philosophical Journal, vol. xix. for 1835, where there is a translation of Boussingault's memoir.

destroyed by the great catastrophe of the 4th February 1797, which in a few minutes destroyed 45,000 human beings. The new Riobamba lies, according to my chronometrical observations, 42 seconds more to the eastward than the old Riobamba, but almost in the same latitude ($1^{\circ} 41' 46''$ south). We were in the plain of Tapia, from which, on the 22d June, we began our expedition towards Chimborazo, being already 8898 Paris feet* (1483 toises) above the level of the South Sea. This table-land is a part of the valley-land between the Eastern and Western Andes, *i. e.* between the chain of the active volcanoes Coto-paxi and Tungurahua on the one hand, and the chain of the Iliniza and Chimborazo on the other. We gently ascended as far as the foot of the last mentioned mountain, where, in the Indian village Calpi, we were to pass the night. This plain is sparingly covered with Cactus stems and *Schinus molle*, which resembles a weeping willow. Herds of variegated llamas, in thousands, seek here a scanty subsistence. At so great a height, the nightly terrestrial radiation of heat, when the sky is cloudless, proves injurious to agriculture, through cold and frost. Before reaching Calpi, we visited Lican, now likewise a small village, but before the conquest of the country by the eleventh Inca, † a considerable city, and the place of residence of the Concho-cando, or Prince of Puruay. The natives believe that the few wild llamas found on the western side of Chimborazo, are derived from dispersed and fugitive herds, which, after the destruction of the old Lican, became wild.

Very near to Calpi, north-westward of Lican, there is in the barren table-land a little isolated hill, the *black mountain*, Yana-Urcu, the name of which has not been given by the French academicians, but which, in a geognostical point of view, deserves much attention. The hill lies S.S.E. of Chimborazo, at a distance of less than three miles (15 to 1°), and separated from the same by the high plain of Luisa only. If in it we do not re-

* Thus 2890 metres. Boussingault calculated this elevation to be 2870 metres, and estimated the mean temperature of the high plain of Tabia at $16^{\circ}.4$ C. ($61^{\circ}.52$ F.)

† The same Tupac-Yupanqui, whose well preserved remains, Garcillasso de la Vega, so lately as in 1559, had seen in the family-vault at Cuzco.

cognise a lateral eruption of Chimborazo, the origin of the cone must certainly be ascribed to the subterranean forces which, under that mountain, have for thousands of years vainly sought an opening. It is of later origin than the elevation of the great dome-shaped mountain. The Yana-Urcu forms, with the northern hill Naguangachi, a connected eminence in the form of a horse-shoe; the bow, more than a semicircle, is open towards the east. There probably lies in the centre of the horse-shoe, the point out of which the black slags have been thrown, that now lie spread far around. We found there a funnel-shaped depression of about 120 feet in depth, in the interior of which there is a small hill, whose height does not equal that of the surrounding margin. Yana-Urcu probably signifies the southern culminating point of the old crater-margin, which, at the most, is elevated 400 feet above the level of Calpi. Naguangachi signifies the northern lower end. The whole eminence reminds one,—through its horse-shoe form, not in regard to its rock,—of the somewhat higher hill Javirac (el Panecillo de Quito), which rises isolated at the foot of the volcano Pichincha, in the plain of Turubamba, and which, in La Condamine's, or rather Morainville's map, is drawn erroneously as a perfect cone. According to the tradition of the natives, and according to old MSS. which the Cacike or Apu of Lican (the Conchocandi) possessed, the volcanic eruption of the Yana-Urcu occurred immediately after the death of the Inca Tupa-Yupanqui:—thus probably in the middle of the 15th century. Tradition says that a fire-ball, or indeed a star, fell from heaven and set on fire the mountain. Such fables, connecting the fall of aërolites with eruptions are also spread among the tribes of Mexico. The rock of the Yana-Urcu is a porous dark clove-coloured, often entirely black slaggy mass, which may be easily confounded with porous basalt. Olivin is entirely wanting in it, the white, sparingly distributed crystals it contains, are throughout small and probably Labrador. Here and there, I saw a sprinkling of iron-pyrites. The whole belongs probably to the black augite-porphry, as well as the whole formation of Chimborazo, of which we shall speak further on, and to which I am not disposed to give the name trachyte, since it contains no felspar, (with some albite), such as is contained in our trachyte of the Siebengebirge near

Bonn. The slaggy masses of the Yana-Urcu altered by a very active fire, are indeed extremely light, but proper pumice-stone has not been thrown out there. The eruption has taken place through a grey, irregularly stratified mass of dolerite, which here forms the table-land, and resembles the rock of Penipe (at the foot of the volcano of Tungurahua) where syenite and mica-slate containing garnets, have been broken through. On the eastern side of the Yana-Urcu, or rather at the foot of the hill towards Lican, the natives conducted us to a projecting rock, an opening in which resembled the mouth of a forsaken gallery. Here, as well as at the distance of ten feet, there is heard a violent subterranean noise, which is accompanied by a current of air, or subterranean wind. The current of air is much too weak to admit of the noise being attributed to it. The noise certainly arises from a subterranean brook, which is precipitated downwards into a deep hollow, and through its fall occasions a motion in the air. A monk, the priest at Calpi, had, with the same idea, some time before, continued on the gallery at an open fissure to procure water for his village. The hardness of the black augite rock probably interrupted the work. Chimborazo, notwithstanding its enormous mass of snow, sends down into the table-land such insignificant brooks of water, that it may be presumed the greater part of its water flows through clefts to the interior. In the village of Calpi itself also, there was formerly heard a great noise in a house that had no cellar. Before the celebrated earthquake of the 4th February 1797, there sprang forth a brook in the south-west of the village, at a deeper point. Many Indians considered this brook as a part of the water that flows under the Yana-Urcu. But since the great earthquake, this brook has again disappeared.

After we had passed the night at Calpi, which, according to my barometrical measurement, lies 9720 feet (1620 toises) above the sea, we began, on the morning of the 23d, our proper expedition up Chimborazo. We attempted to ascend the mountain on the S. E. side, and the Indians who were to attend us as guides, but of whom but a few had ever reached the limit of perpetual snow, gave this course the preference. We found Chimborazo surrounded with great plains, which rise,

step-like, one above the other. Proceeding first through the Llanos de Luisa, then after rather a gradual ascent of scarcely 5000 feet in length, we reached the table land (Llano) of Sisgun. The first step (stufe) is at a height of 10,200 feet, the second 11,700. These grass grown plains thus equal in elevation, respectively, the highest summit of the Pyrenees (Peak Nethou) and the summit of the Peak of Teneriffe. The perfect horizontality of these table-lands allows us to infer the long continuance of stagnant water. The traveller imagines he sees before him the bottom of a lake. On the acclivity of the Swiss Alps, there is sometimes observed this phenomenon of small step-like plains, lying one above the other, which, like the emptied basins of alpine lakes, are united by narrow open passes. The widely extended grass lands (los Pajonales) are on Chimborazo, as everywhere around the high summits of the Andes, so monotonous that the family of the grasses (species of *Paspalum*, *Andropogon*, *Bromus*, *Dejeuxia*, *Stipa*) are seldom interrupted by dicotyledonous plants. There prevails almost the heathy scenery which I have seen in the barren part of Northern Asia. The flora of Chimborazo, in general, appeared to us less rich than that of the other snow mountains which surround the city of Quito. But a few *Calceolariæ*, *Compositæ*, (*Bidens*, *Eupatorium*, *Dumerilia paniculata*, *Werneria nubigena*) and *Gentianæ*, among which the beautiful *Gentiana cernua* shining forth with purple flowers,—rear themselves on the high plain of Sisgun, between the associated grasses. These belong, for the most part, to the genera of Northern Europe. The temperature of the air generally prevailing in these regions of alpine grasses, elevated respectively 1600 and 2000 toises, fluctuates by day between 4° and 16° C. ($39^{\circ}.2$ and $60^{\circ}.8$ F.), by night between 0° and 10° (32° and 50° F.). The mean temperature of the whole year, according to my collective observations in the neighbourhood of the Equator, appears to be about 9° * ($48^{\circ}.2$ F.). In the flat lands of the Temperate Zone, this is the mean temperature of the north of Germany,

* All temperatures mentioned in this paper are expressed in degrees of the centigrade thermometer. (The equivalent degree of Fahrenheit have been since added —T.R.)

for example, of Luneburg (Lat. $53^{\circ}15'$); but here the distribution of heat among the different months (the most important element in determining the character of the vegetation of a country) is so unequal, that in February, the mean heat is $-1^{\circ}.8$ ($+28^{\circ}.76$ F.), in July $+18^{\circ}$ ($+64^{\circ}.4$ F.)

My plan was to perform a trigonometrical operation in the beautiful perfectly level grass land of Sisgun. I had made arrangements for measuring a base line here. The angles of altitude would have proved very considerable in such proximity to the summit of Chimborazo. There remained yet a perpendicular height of less than 8400 feet (the height of the Canigou in the Pyrenees) to determine. Yet with the enormous masses of single mountains in the chain of the Andes, every determination of the height above the sea is compounded of a barometrical and trigonometrical observation. I had taken with me the sextant and other instruments of measurement in vain. The summit of Chimborazo remained densely veiled in mist. From the high plain of Sisgun the ascent is tolerably steep as far as the little alpine lake of Yana-Coche. Thus far I had remained on the mule, having from time to time alighted with my travelling companion M. Bonpland merely to collect plants. Yana-Coche does not deserve the name of a lake. It is a circular basin of scarcely 130 feet in diameter. The sky became more and more obscured; but between and over the mist-strata there still lay scattered single groups of clouds. The summit of Chimborazo was visible for a few moments only at a time. Much snow having fallen during the preceding night, I left the mule where we found the lower border of this newly-fallen snow, a border which must not be confounded with the limit of perpetual snow. The barometer shewed that we had only now attained the height of 13,500 feet. On other mountains, likewise near to the equator, I have seen snow fall at the height of 11,200 feet, but not lower. My companion rode as far as the line of perpetual snow, *i. e.* to the height of Mont Blanc; which mountain, as is known, would not in this latitude ($1^{\circ} 27'$ south) always be covered with snow. The horses and mules remained there to await our return.

A hundred and fifty toises above the little basin of Yana-Coche, we saw at length naked rock. Hitherto the grass-land

had withdrawn the ground from any geognostical examination. Great walls of rocks, extending from the N. E. towards the S. W., in part cleft into misshapen columns, reared themselves out of the eternal snow,—a brownish-black augite rock shining like pitch-stone porphyry. The columns were very thin, perhaps fifty to sixty feet in height, almost like the trachyte columns of Tabla-Umea on the volcano Pichincha. One group stood alone, and reminded one of masts and stems of trees. The steep walls led us through the snow region to a narrow ridge of rock extending towards the summit, by which alone it was possible for us to advance any farther; for the snow was then so soft that one scarcely dared to tread upon its surface. The ridge consisted of very weathered crumbling rock. It was often vesicular like a basaltic-amygdaloid.

The path became more and more narrow and steep. The natives forsook us all but one at the height of 15,600 feet. All entreaties and threats were unavailing. The Indians maintained that they suffered more than we did from breathlessness. We remained alone, Bonpland,—our amiable friend the younger son of the Marquis of Selvaegre, Carlos Montufar, who, in the subsequent struggle for freedom, was shot, (at the command of General Morillo),—a Mestize from the neighbouring village of San Juan,—and myself. We attained, with great exertion and endurance, a greater height than we had dared hope to reach, as we were almost entirely wrapped in mist. The ridge (very significantly called, in Spanish, Cuchilla, as it were the knife-back) was in many places only eight to ten inches broad. On the left the precipice was concealed by snow, the surface of the latter seeming glazed with frost. The thin icy mirror-like surface had an inclination of about 30°. On the right our view sank shuddering 800 or 1000 feet into an abyss out of which projected, perpendicularly, snowless masses of rock. We held the body continually inclined towards this side, for the precipice upon the left seemed still more threatening, because there no chance presented itself of grasping the toothed rock, and because, further, the thin ice-crust offered no security against sinking in the loose snow. Only extremely light porous bits of dolerite could we roll down this crust of ice; and the inclined plane of snow was so extended that we lost

sight of the stones thus rolled down before they came to rest. The absence of snow, as well upon the ridge along which we ascended, as upon the rocks on our right hand towards the east, cannot be ascribed so much to the steepness of the masses, and to the gales of wind, as to open clefts, which breathe out warm air from deeper situated beds. We soon found our further ascent more difficult, from the increase of the crumbling nature of the rock. At single and very steep *échelons* it was necessary to apply at the same time the hands and feet, as is so usual in all alpine journeys. As the rock was very keenly angular, we were painfully hurt, especially in the hands. Leopold Von Buch and I suffered very much in this manner near the crater of the Peak of Teneriffe, which abounds in obsidian. I had had besides (if it be permitted a traveller to mention such unimportant particulars) for several weeks a sore in the foot, occasioned by the accumulations of Niguas * (*Pulex penetrans*), and much increased by fine dust of pumice-stone during measurements in Llano de Tapia. The little adhesion of the rocks upon the ridge now rendered greater caution necessary, as many masses which we supposed firm lay loose and covered with sand. We proceeded one after the other, and so much the more slowly, as it was needful to try the places which seemed uncertain. Happily the attempt to reach the summit of Chimborazo was the last of our mountain journeys in South America; hence previous experience guided us, and gave us more confidence in our powers. It is a peculiar character of all excursions in the Andes, that above the snow-line white people find themselves in the most perilous situations, always without guides, indeed without any knowledge of localities.

We could see the summit no longer, even for a moment only at a time, and were hence doubly curious to know, how much higher it remained for us to ascend. We examined the barometer at a point where the breadth of the ridge permitted of two persons standing conveniently together. We were now at an elevation of 17,300 feet; thus scarcely two hundred

* The Sand-flea, the Chique of the French colonists of the West Indies, an insect that introduces itself under the human skin, and, as the ovary of the impregnated female considerably enlarges, inflammation is excited.

feet higher than we had been two months before, when climbing a similar ridge on the Antisana. It is with the determining of heights in climbing mountains, as with the determining of temperature in the heat of summer. One finds with vexation the thermometer not so high, the barometer not so low, as one expected. As the air, notwithstanding the height, was quite saturated with moisture, we now found the loose rock and the sand that filled its interstices extremely wet. The air was still $2^{\circ} 8'$ ($37^{\circ} 04'$ Fahr.) Shortly before, we had in a dry place been able to bury the thermometer three inches deep in the sand. It indicated $+5^{\circ} 8'$ ($+42^{\circ} 44'$ Fahr.) The result of this observation, which was made at the height of about 2860 toises, is very remarkable, for 400 toises lower down, at the limit of perpetual snow, the mean heat of the atmosphere is, according to many observations, carefully collected by Boussingault and myself, only $+1^{\circ} 6'$ ($34^{\circ} 88'$ Fahr.) The temperature of earth (sand) at $+5^{\circ} 8'$ ($42^{\circ} 44'$ Fahr.) must therefore be ascribed to the subterranean heat of the dolerite mountain; I do not say to the whole mass, but to the current of air ascending from the interior.

After an hour of cautious climbing, the ridge of rock became less steep; but alas! the mist remained as thick as ever. We now began gradually to suffer from great nausea. The tendency to vomiting was combined with some giddiness; and much more troublesome than the difficulty of breathing. A coloured man (a mestize of San Juan), not from selfish motives, but merely out of good nature, had been unwilling to forsake us. He was a poor vigorous peasant, and suffered more than we did. We had hæmorrhage from the gums and lips. The conjunctiva of the eyes likewise, was, in all, gorged with blood. These symptoms of extravasation in the eyes, and of oozing from the lips and gums, did not in the least disquiet us, as we had repeatedly experienced them before. In Europe, M. Zumstein began to experience hæmorrhage at a much lower elevation on Monte Rosa. The Spanish warriors during the conquest of the equinoctial region of America (during the Conquista), did not ascend above the snow line, thus but little above the elevation of Mont Blanc, and yet Acosta, in his *Historia Natural de las Indias*,—a kind of physical geography, which may be called a master-piece of the 16th century,—speaks circumstantially of “Nausea and Spasm

of the Stomach," as painful symptoms of the *mountain-sickness*, which in these respects is analogous to *sea-sickness*. On the volcano of Pichincha I once felt, without experiencing hæmorrhage, so violent an affection of the stomach, accompanied by giddiness, that I was found senseless on the ground, just as I left my companions on a wall of rock above the defile of Verde-Cueha, in order to perform some electrical experiments on a perfectly open space. The height was inconsiderable, below 13,800 feet. But on the Antisana, at the considerable elevation of 17,220 feet, our young travelling companion, Don Carlos Montufar, bled freely from the lips. All of these phenomena vary according to age, constitution, the tenderness of the skin, the preceding exertions of the muscular powers; yet for single individuals they are a kind of measure of the atmospheric tenuity, and of the absolute elevation reached. According to my observations in the Cordilleras, these symptoms manifest themselves in white people, with a mercurial column between 14 inches,—and 15 inches 10 lines. It is known that the estimates regarding heights, which aeronauts maintain that they have reached, generally deserve but little credit, and if a more certain and extremely accurate observer, M. Gay Lussac, who, on the 16th of September 1804, reached the vast height of 21,600 feet (thus between the height of Chimborazo and Illimani), experienced no hæmorrhage, this is perhaps to be ascribed to the absence of muscular exertion. According to the present condition of eudiometry, the air of those lofty regions appear to contain in proportion as much oxygen as that of lower heights; but since in that attenuated air—the barometric pressure only one-half of that to which we are generally exposed—the blood in each act of respiration takes up a smaller quantity of oxygen, it is certainly conceivable that a general feeling of weakness should take place. Why this asthenie as in fainting, should excite nausea and a tendency to vomiting, it is not our purpose to determine; as little is it here to be proved, that the oozing of blood (the hæmorrhage from the lips, gums, and eyes), which also has not been experienced by all, at such great heights,—can by no means be satisfactorily explained by the absence of a "mechanical counter-pressure" on the vascular system; our attention should rather be engaged in examining the probability of the influence of a

diminished atmospheric pressure, during fatigue, on the moving of the legs in regions of very attenuated air; for, according to the memorable discovery of two spirited inquirers, Wilhelm and Edward Weber,* the hovering leg, hanging from the trunk, is held and carried merely by the pressure of the atmosphere.

The layers of mist that prevented our seeing distant objects, appeared suddenly, notwithstanding the total stillness of the air, perhaps through electrical processes, to be broken up. We recognised once more, and indeed immediately before us, the dome-shaped summit of Chimborazo. It was an earnest, momentous gaze. The hope to reach this summit animated our powers anew. The ridge of rock, only here and there covered with thin flakes of snow, became somewhat broader. We hastened onwards, with certain steps, when all at once a ravine of some 400 feet in depth, and 50 broad, set an insurmountable barrier to our undertaking. We saw distinctly beyond the abyss, our ridge of rock continued forward in the same direction; yet I doubt its leading to the summit itself. The chasm was not to be gone round. On the Antisana, M. Bonpland indeed had found it possible, after a very cold night, to proceed for a considerable length through the snow. We durst not venture the attempt, because of the looseness of the mass, and the form of the precipice rendered climbing down impossible. It was one o'clock in the afternoon. We set up with much care the barometer. It indicated 13 inches $11\frac{2}{10}$ lines. The temperature of the air was now $-1^{\circ} 6'$ ($+ 29^{\circ} 12'$ F.), but after several years' stay in the hottest regions of the Tropics, this small degree of cold benumbed us. Besides, our boots were thoroughly soaked with snow-water, for the sand that covered here and there the ridge was mixed with old snow. According to La Place's barometrical formula, we had reached a height of 3016 toises, or more precisely 18,097 Paris feet. If La Condamine's estimate of the height of Chimborazo, as noted on the stone-table of the Jesuit's College in Quito, be correct, there failed us

* *Mechanik der Menschlichen Werkzeuge*. 1836. § 64. S. 147-160. More recent experiments of the brothers Weber, at Berlin, have fully confirmed the position, that the leg is carried in the acetabulum by the pressure of the atmosphere.

yet of the summit of the mountain 1224 feet, or thrice the height of St Peter's church at Rome.

La Condamine and Bouguer say explicitly, that they attained, on Chimborazo, the height of 2400 toises only ; but they glory in having seen on the Corazon,—one of the most picturesque snow-mountains (Nevados) in the immediate neighbourhood of Quito,—the barometer at 15 inches 10 lines. They say this is “ a lower state than any human being has hitherto ever been in a situation to observe.” At the above described point on Chimborazo, the pressure of the air was about two inches less ; less also than at the highest point reached in 1818, sixteen years afterwards, by Captain Gerard, on the Tarhigang, in the Himalayan Mountains. I have been exposed in a diving-bell in England to an air-pressure of forty-five inches, for almost an hour together. The flexibility of the human organism consequently endures changes in the state of the barometer, amounting to thirty-one inches. Yet the physical constitution of the human race might be remarkably changed, if great cosmical causes were to make permanent such extremes in atmospheric tenuity and condensation.

We remained but a short time in this mournful solitude, being soon again entirely veiled in mist. The humid air was not thereby set in motion. No fixed direction was to be observed in single groups of the denser particles of vapour ; I therefore cannot say whether at this elevation the west wind blows, opposing the Tropical monsoon. We saw no longer the summit of Chimborazo, none of the neighbouring snow-mountains, still less the table-lands of Quito. We were as though isolated in a ball of air. Some stone-lichens only had followed us above the line of perpetual snow. The last cryptogamic plants which I collected were *Lecidea atrovirens* (Lichen geographicus, *Web.*), and a *Gyrophora* of *Acharius*, a new species (*Gyrophora rugosa*), at about the height of 2820 toises. The last moss, *Grimmia longirostris*, grew 400 toises lower down. A butterfly (sphinx) was caught by M. Bonpland at the height of 15,000 feet ; we saw a fly 1600 feet higher. The following facts afford the most striking proof that these animals are involuntarily carried up into those upper regions by the current of air which rises from the warmed plains. As Boussingault ascended the

Silla de Caracas, to repeat my measurement of the mountain, he saw from time to time, at the height of 8000 feet, at noon, as the west wind blew, whitish bodies rapidly pass through the air, which he at first took for soaring birds with white plumage, that reflected the sun's rays. These bodies rose with great rapidity out of the valley of Caracas, and surmounting the summit of Silla, took a north-east direction, and reached probably the sea. Some fell upon the southern acclivity of the Silla; they were grass-halms, that had reflected the sun's rays. Boussingault sent me some of these, which still had ears, in a letter to Paris, where my friend and fellow-labourer Kunth instantly recognised them as the *Wilfa tenacissima*, which grows in the valley of Caracas, and which he has described in our work, *Nova Genera et Species Plantarum Americæ Æquinoctialis*. I must remark, that we met with no condor on Chimborazo, that powerful vulture, which is so frequent on Antisana and Pichincha, and which shews great confidence from its ignorance of man. The condor loves pure air, in order the easier from on high to recognise its prey or its food, for it gives dead animals the preference.

As the weather became more and more cloudy, we hastened down upon the same ledge of rock, that had favoured our ascent. Caution, however, on account of the uncertainty of the steps, was more necessary than in climbing up. We tarried only just to collect fragments of rock. We foresaw, that in Europe "a little bit of Chimborazo" would be asked for. At that time, no mountain rock in any part of South America had been named; the rocks of all the high summits of the Andes were called granite. As we were at the height of about 17,400 feet, it began to hail violently. The hailstones were opaque, and milk-white, with concentric layers. Some appeared considerably flattened by rotation, twenty minutes before we reached the lower limit of perpetual snow, the hail was replaced by snow. The flakes were so dense, that the snow soon covered the ridge of rock many inches deep; we should have been brought into great danger, had the snow surprised us at the height of 18,000 feet. At a few minutes after two o'clock, we reached the point where our mules were standing. The natives that remained behind, had been very apprehensive for our safety.

That part of our expedition which lay above the snow-line, had lasted only $3\frac{1}{4}$ hours, during which, notwithstanding the tenuity of the air, we had not found it needful to take rest by sitting down. The diameter of the dome-shaped summit at the snow-line—*i. e.* at the height of 2460 toises—amounts to 3437 toises, and near the apex, about 150 toises below the same, the diameter is 672 toises. The last number is thus the diameter of the upper part of the dome or bell; the first expresses the breadth, of which the whole snow-mass of Chimborazo appears to the eye, as seen from Rio Nuevo; a mass which, together with the two mountain-tops lying to the north, is represented in the 16th and 25th table of my engraved work, *Vues des Cordillères*. I have carefully measured with the sextant, the single parts of the contour, as the latter, on a clear day, magnificently stands forth in opposition to the deep-blue of a tropical sky. Such observations assist in thoroughly exploring the volume of this colossus, in so far as it surmounts a plain, in which Bonguer performed his experiments on the attraction of the mountain for a pendulum. A distinguished geognost, M. Pentland, to whom we are indebted for a knowledge of the heights of Sorata and Illimani, and who, furnished with excellent instruments for astronomical and physical research, is now again going to upper Peru (Bolivia) has assured me, that my figure of Chimborazo is, as it were, repeated in the Nevado de Chuquibamba, a trachyte mountain of the Western Cordilleras, north of Arequipa, having a height of 19,680 feet (3280 toises). Next to the Himalayan mountains, this is, owing to the frequency of high summits and the mass of the same, between the 15th and 18th degree of south latitude the greatest enlargement on the earth's surface, with which we are acquainted, in so far namely, as this enlargement proceeds, not from the primitive form of the revolving planet, but from the elevation of mountain-chains and single domes of dolerite, trachyte, and albite rock, within these mountain-chains.

On account of the snow newly fallen, we found in our descent from Chimborazo, the lower limit of perpetual snow, in accidental and temporary conjunction with the deeper sporadial spots of snow on the naked lichen-covered rocks, and on the grass plain (Pajonal); yet it was always easy to recognise the proper limit of perpetual snow (then at the height of 2470 toises) by the thickness of the bed and by its peculiar state. I have

shewn, in another place (in a treatise on the causes which conditionate the curvature of *isothermal lines* incorporated into one of the *fragmens Asiatique*), that in the province of Quito, the differences in height of the snow-line on the different *Nevados*, according to the sum-total of my measurements, varies only about 38 toises,—that the mean height itself is to be reckoned 14,760 feet, or 2460 toises,—and that this limit in Bolivia, 16° to 18° south of the equator, on account of the relation of the mean annual temperature to the mean temperature of the hottest months, on account of the mass, extent, and greater height of the surrounding heat-radiating *plateaus*, on account of the dryness of the atmosphere, and the complete absence of any falling snow between March and November, lies at a height of full 26,780 toises. The lower limit of perpetual snow, which by no means coincides with the isothermal curve of 0°, rises consequently higher, as an exception, instead of falling, as one recedes from the equator. From quite analogous causes of the radiation of heat in neighbouring table-lands, the snow-line lies between 30 $\frac{3}{4}$ ° and 31° of northern latitude, on the northern Thibet side of the Himmalayan range, at the height of 2600 toises; while on the southern Indian side, it reaches the height of only 1950 toises. Through this remarkable influence of the shape of the earth's surface, a considerable part of inner Asia, beyond the Tropics, is inhabited by an agricultural population, who, though monk-governed, are advanced in civilization; where in South America, under the equator, the ground is covered with eternal ice.

We took a somewhat more northern way back to the village of Calpi than the Llanas de Sisgum, through the Paramo de Pungupala, a district rich in plants. By five o'clock in the evening we were again with the friendly clergyman of Calpi. As usual, the misty day of the expedition was succeeded by the clearest weather. On the 25th of June, at Riobamba Nuevo, Chimborazo presented itself in all its splendour,—I may say, in the calm greatness and supremacy which is the natural character of the tropical landscape. A second attempt upon a ridge interrupted by a chasm, would certainly have turned out as fruitless as the first, and I was already engaged with the trigonometrical measurement of the volcano of Tungurahua.

Boussingault, on the 16th of December 1831, with his English friend Colonel Hall,—who was soon afterwards assassinated in Quito,—made a new attempt to reach the summit of Chimborazo, first from Mocha and Chillapullu, then from Arenal, thus by a different way from that trodden by Bonpland, Don Carlos Montufar, and myself. He was obliged to give up the ascent, when his barometer indicated 13 inches $8\frac{1}{2}$ lines, with an atmospheric temperature of $+7^{\circ}.8$ ($+46^{\circ}.04$ F.). He thus saw the uncorrected column of mercury almost three lines lower, and reached a point 64 toises higher than I did, viz. 3080 toises. Let us have the words of this well-known traveller of the Andes, who was the first to carry a chemical apparatus to, and into, the craters of volcanoes. “The way,” says Boussingault, “which we opened for ourselves through the snow, in the latter part of our expedition, permitted of our advancing but very slowly. On the right we were enabled to grasp hold of a rock, on the left, the abyss was fearful. We were already sensible of the effect of the attenuated air, and were obliged, every two or three steps, to sit down. As soon, however, as we were seated, we again stood up, for our sufferings lasted only while we moved. The snow we were obliged to tread was soft, and lay three or four inches deep, on a very smooth and hard covering of ice. We were obliged to hew out steps. A Negro went before, to perform this work, by which his powers were soon exhausted. As I was endeavouring to pass him, for the purpose of relieving him, I slipped, and happily was held back by Colonel Hall and my Negro. We were (adds M. Boussingault) for a moment all three in the greatest danger. Further on, the snow became more favourable, and at three quarters past three o’clock we stood upon the long-looked for ridge of rock, which was only a few feet broad, and surrounded by immeasurable depths. Here we became convinced that to advance farther was impossible. We found ourselves at the foot of a prism of rock, whose upper surface, covered with a cap of snow, forms the proper summit of Chimborazo. To have a true figure of the topography of the whole mountain, one must imagine an enormous snow-covered mass of rock, which from all sides appears as if supported by buttresses. The latter are the ridges, which, ad-

herent, project through the eternal snow." The loss of a natural philosopher, like Boussingault, would have been indescribably dearly-bought with the little gain which undertakings of this sort can afford to science.

Although, thirty years ago, I expressed the wish that the height of Chimborazo might be again trigonometrically measured, there yet remains some uncertainty as to the absolute result. Don Jorge Juan and the French Academicians, after different combinations of the same elements, or at least after operations, the whole of which were in common, give the heights of 3380 and 3217 toises; heights which present a difference of $\frac{1}{20}$ th. The result of my trigonometrical operation (3350 T.) falls between them, but approaches to within $\frac{1}{12}$ th of the Spanish estimate. Bouguer's lesser result is founded, in part at least, upon the height of the city of Quito, which he estimated at 30 to 40 toises too low. He gives, according to old barometric formula, without correction for the temperature, the height of 1462, instead of 1507 and 1492 toises, the very accordant results, respectively, of Boussingault's observations and my own. The height at which I estimate the plain of Tapia, where I measured a base of 873 toises in length,* also appears to be pretty free from error. I found the same to be 1482 toises; and Boussingault, at a very different season of the year, and thus with other diminutions of temperature in the atmospheric strata, 1471 toises. Bouguer's operation was, on the other hand, very complicated, as he was obliged to estimate the height of the valley-plain, between the eastern and western Andes, by means of very small angles of height of the trachyte-pyramid of Ilinissa, measured in the under region of the coast. The only considerable mountain of the earth, of which the measurements now agree within $\frac{1}{48}$ th, is Mont Blanc; for Monte Rosa was, with four different series of triangles by an excellent observer, the astronomer *Carlini*, estimated at 2319, 2343, 2357, and 2374 toises; by *Oriani*, likewise by triangulation, at 2390 toises; differences of $\frac{1}{4}$ th. The oldest detailed mention of Chimborazo, I find to be that of the spirited, somewhat

* *Humboldt*, Recueil d'observations astronomiques, d'operations trigonometriques, etc. T. I. p. lxxii.

satirical, Italian traveller, Girolamo Benzoni, whose work was printed in 1565. He says, that the Montagna di Chimbo, 40 *miglia* high, appeared to him strangely *come una visione*. The natives of Quito knew, long before the arrival of the French surveyors, that Chimborazo was the highest snow-mountain in all their country. They saw that it ascended highest above the line of perpetual snow. It was just this consideration that induced them to consider the now fallen in Capac Urcu as higher than Chimborazo.

Regarding the geognostical constitution of Chimborazo, I here add only the general remark, that if, according to the important results which Leopold von Buch has laid down in his classical memoir, “On Craters of Elevation and Volcanoes,*” Trachyte is a mass containing Felspar, and Andesite a mass with imbedded Albite; the rock of Chimborazo is by no means deserving of either name. That in Chimborazo, Augite replaces Hornblende, the same intelligent geognost observed, more than twenty years ago, when I requested him to examine, oryctognostically and with precision, the rocks brought home by me from the Andes. This fact has been mentioned in several parts of my “*Essai geognostique sur le Gisement des Rochers dans les deux Hémisphères*,” which appeared in the year 1823. Besides this, my Siberian travelling companion, *Gustav Rose*, who, by his excellent work on the minerals related to felspar, and their association with augite and hornblende, has opened new ways for geognostical research, finds in all my collection of mountain-fragments from Chimborazo, neither albite nor felspar. The whole formation of this celebrated summit of the Andes, consists of labrador and augite; both fossils recognisable in distinct crystals. Chimborazo is, according to the nomenclature of *Gustav Rose*, an augite-porphry, a species of dolerite. Obsidian and pumice stone are also wanting in it. Hornblende occurs very sparingly. Chimborazo is thus, as taught by Leopold von Buch’s and Elie de Beaumont’s latest decisions, analogous in its rock to Etna. With the ruins of the old city of Riobamba, three geographical miles east of Chimborazo, there

* *Poggendorff’s Annalen*, Band. 37. S. 188—190. Also *Edinburgh New Philosophical Journal*, for translation of this memoir.

is associated true diorite-porphry, a mixture of black hornblende (without augite) and white glassy albite, a rock which reminds one of the beautiful columnar masses of Pisoje near Popayan, and of the Mexican volcano of Toluca; which also, I ascended. Some of the pieces of augite-porphry, which I found as high up as 18,000 feet upon the ridge of rock leading towards the summit, for the most part in loose pieces, of from 12 to 14 inches in diameter, are minutely porous, and red in colour. These pieces have shining vesicular cavities. The blackest are sometimes light, like pumice-stones, and as if recently changed by fire. They have not, however, flown in streams like lava, but have probably been thrust out through fissures, on the side of the earlier raised-up dome-shaped mountain. The whole table-land of the province of Quito has always been considered by me as a great volcanic area. Tungurahua, Cotopaxi, Pichincha, with their craters, are only different openings of this area. If volcanism, in the broadest sense of the word, marks all the appearances which depend on the reaction of the interior of a planet on its oxydized surface, this part of the high land is more exposed than any other in the tropical region of South America, to the effect of this volcanism. The volcanic powers rage also, under the domes of augite-porphry, which, like that of Chimborazo, have no crater. Three days after our expedition, we heard, in New Riobamba, at one o'clock A. M., a raging subterranean crash (*bramido*) that was accompanied by no concussion. Three hours later, there followed a violent earthquake, without any preceding noise. Similar *bramidos*, coming, as it is supposed, from Chimborazo, were perceived some days before at Calpi. Nearer to this mountain-Colossus, in the village of San Juan, they are extremely frequent. They excite the attention of the natives no more, than distant thunder out of a deeply-clouded sky does in our northern zone.

These are the few fugitive remarks on two ascents of Chimborazo, which I have allowed myself to communicate from an unprinted journal. Where Nature is so mighty and so vast, and our endeavours are purely scientific, the exhibition of any ornament in language may well be spared.



